We claim:

1. A method for producing a shrunken replica or a shrunken inverse replica of a multicontinuous structure, the method comprising:

infiltrating a first multicontinuous structure with a first fluid material which can be immobilized and shrunken, wherein the first multicontinuous structure comprises at least a first phase and a second phase which is immiscible with the first phase, and the infiltration displaces the second phase in the first multicontinuous structure to form a second multicontinuous structure which comprises at least the first phase and a third phase which consists of the first fluid material;

immobilizing the infiltrated first fluid material in the second multicontinuous structure;

removing the first phase from the second multicontinuous structure; and

shrinking the third phase of the second multicontinuous structure, to produce an isotropically shrunken inverse replica of the first multicontinuous structure.

2. The method of claim 1, further comprising:

infiltrating the shrunken inverse replica with a second fluid material which can be immobilized, wherein the shrunken inverse replica comprises at least a first phase and a second phase which is immiscible with the first phase, and the infiltration displaces the second phase of the shrunken inverse replica to form a third multicontinuous structure which comprises the first phase and a third phase which consists of the second fluid material which is immiscible with the first phase; and

immobilizing the infiltrated second fluid material in the third multicontinuous structure.

3. The method of claim 2, further comprising removing the first phase from the third multicontinuous structure, to produce an isotropically shrunken direct replica of the first multicontinuous structure.

4. The method of claim 3, further comprising:

infiltrating the isotropically shrunken direct replica with a third fluid material which can be immobilized and shrunken, wherein the shrunken replica comprises at least a first phase and a second phase which is immiscible with the first phase, and the infiltration displaces the second phase in the shrunken replica;

immobilizing the infiltrated third fluid material in the shrunken replica;

removing at least the first phase from the shrunken replica; and

shrinking the third phase of the shrunken replica, to produce a second isotropically shrunken inverse replica of the first multicontinuous structure.

5. The method of claim 1, wherein the multicontinuous structure is an ordered bicontinuous structure or a disordered bicontinuous structure.

6. The method of claim 1, wherein the first multicontinuous structure is formed by a molding process, a solid free form fabrication process, or a biological process.

7. The method of claim 1, wherein the volume of the inverse replica is between about 1 % and about 90 % of the volume of the first multicontinuous structure.

8. The method of claim 1, wherein the first fluid material which can be immobilized and shrunken comprises a monomer or other polymer precursor.

9. The method of claim 8, wherein the polymer precursor comprises an organometallic precursor.

10. The method of claim 8, wherein the polymer precursor is a precursor of polysilazanes, poly(isopropyliminoalane), or polyborosiloxanes.

11. The method of claim 8, wherein the polymer precursor comprises dimethyl siloxane.

12. The method of claim 8, wherein the immobilization comprises polymerizing or crosslinking the monomer or polymer precursor.

13. The method of claim 2, wherein the second fluid material comprises a molten metal or semi-metal.

14. The method of claim 13, wherein the immobilization comprises freezing the metal.

15. The method of claim 2, wherein the second fluid material comprises a monomer or other polymer precursor.

16. The method of claim 4, wherein the first fluid material and the third fluid material each comprise the same polymer precursor.

17. The method of claim 1, wherein the second phase is air or another gas and the infiltration is conducted under vacuum conditions.

18. The method of claim 1, wherein the removal of the first phase from the second multicontinuous structure comprises removing the first phase with a solvent which is a nonsolvent for the third phase.

19. The method of claim 1, wherein the removal of the first phase from the second multicontinuous structure comprises a process selected from the group consisting of UV degradation, ozone etching, reactive ion etching, chemical etching, and laser ablation.

20. The method of claim 1, wherein the shrinking of the third phase of the second multicontinuous structure comprises pyrolysis of the third phase.

21. The method of claim 20, wherein the third phase comprises polydimethylsiloxane and the pyrolysis converts the polydimethylsiloxane to a silicon oxycarbide.

22. The method of claim 1, wherein the infiltration of the first fluid material comprises a gas phase deposition process.

23. A method for producing a shrunken replica of a bicontinuous structure, the method comprising:

infiltrating a first bicontinuous structure with a first fluid material which can be immobilized, wherein the first bicontinuous structure comprises a first phase and a second phase which is immiscible with the first phase, the backfilling displacing the second phase in the first bicontinuous structure to form a second bicontinuous structure which comprises the first phase and a third phase which consists of the first fluid material which is immiscible with the first phase;

immobilizing the infiltrated first fluid material in the second bicontinuous structure;

removing the first phase from the second bicontinuous structure, to produce an inverse replica of the first bicontinuous structure;

infiltrating the inverse replica with a second fluid material which can be immobilized and shrunken, wherein the inverse replica comprises at least a first phase and a second phase which is immiscible with the first phase, and the infiltration displaces the second phase of the inverse replica to form a third bicontinuous structure which comprises the first phase and a third phase;

immobilizing the infiltrated second fluid material in the third bicontinuous structure;

removing the first phase from the third bicontinuous structure; and

shrinking the third phase of the third bicontinuous structure, to produce an isotropically shrunken replica of the first bicontinuous structure.

24. The method of claim 23, further comprising:

infiltrating the shrunken replica with a third fluid material which can be immobilized, wherein the shrunken replica comprises at least a first phase and a second phase which is immiscible with the first phase, and the infiltration displaces the second phase of the shrunken replica to form a fourth bicontinuous structure which comprises the first phase and a third phase; and

immobilizing the infiltrated third fluid material in the fourth bicontinuous structure.

25. The method of claim 24, further comprising removing the first phase from the fourth bicontinuous structure, to produce an isotropically shrunken inverse replica of the first bicontinuous structure.

26. The method of claim 23, wherein the first bicontinuous structure is formed by a molding process, a solid free form fabrication process, or a biological process.

27. The method of claim 23, wherein the volume of the shrunken replica is between about 1 % and about 90 % of the volume of the first bicontinuous structure.

28. The method of claim 23, wherein the first fluid material which can be immobilized and shrunken comprises a monomer or other polymer precursor.

29. The method of claim 28, wherein the polymer precursor comprises an organometallic precursor.

30. The method of claim 28, wherein the polymer precursor is a precursor of polysilazanes, poly(isopropyliminoalane), or polyborosiloxanes.

31. The method of claim 28, wherein the polymer precursor comprises dimethyl siloxane.

32. The method of claim 28, wherein the immobilization comprises polymerizing or crosslinking the monomer or polymer precursor.

33. The method of claim 23, wherein the second fluid material comprises a molten metal or semi-metal.

34. The method of claim 33, wherein the immobilization comprises freezing the metal.

35. The method of claim 23, wherein the second fluid material comprises a monomer or other polymer precursor.

36. The method of claim 23, wherein the first fluid material and the third fluid material each comprise the same polymer precursor.

37. The method of claim 23, wherein the second phase is air or another gas and the infiltration is conducted under vacuum conditions.

38. The method of claim 23, wherein the removal of the first phase from the second bicontinuous structure comprises removing the first phase with a solvent which is a nonsolvent for the second phase.

39. The method of claim 23, wherein the removal of the first phase from the second bicontinuous structure comprises a process selected from the group consisting of UV degradation, ozone etching, reactive ion etching, chemical etching, and laser ablation.

40. The method of claim 23, wherein the shrinking of the third phase of the third bicontinuous structure comprises pyrolysis of the third phase.

41. The method of claim 40, wherein the third phase comprises polydimethylsiloxane and the pyrolysis converts the polydimethylsiloxane to a silicon oxycarbide.

42. The method of claim 23, wherein the infiltration of the first fluid material comprises a gas phase deposition process.

43. A method for producing a shrunken replica a multicontinuous structure, the method comprising:

(a) providing a first multicontinuous structure which comprises at least a first solid phase and a second phase comprising gas-filled or evacuated interconnected pores;

(b) shrinking the first solid phase by a pyrolysis process;

(c) infiltrating the pores with a first fluid material;

(d) immobilizing the first fluid material to form a second multicontinuous structure which comprises the shrunken first solid phase and a third phase consisting of the immobilized first fluid material; and

(e) removing the first solid phase, to yield a shrunken inverse replica which comprises the third phase and a fourth phase consisting of gas-filled or evacuated interconnected pores.

44. The method of claim 43, further comprising:

(g) shrinking the third phase by a pyrolysis process;

(h) infiltrating the pores of the fourth phase with a second fluid material;

(i) immobilizing the second fluid material to form a third multicontinuous structure which comprises the shrunken third phase and a fifth phase consisting of the immobilized second fluid material; and

(j) removing the shrunken third phase, to yield a shrunken direct replica which comprises the fifth phase and a sixth phase consisting of gas-filled or evacuated interconnected pores.

45. A replica of a multicontinuous structure made by the process of claim 1.

46. A replica of a bicontinuous structure made by the process of claim 23.

47. A replica of a multicontinuous structure made by the process of claim 43.